

TITLE OF THE INVENTION

DIGITAL WATERMARK EMBEDDING METHOD, DIGITAL WATERMARK
EXTRACTION METHOD, DIGITAL WATERMARK EMBEDDING
APPARATUS, AND DIGITAL WATERMARK EXTRACTION APPARATUS

5

FIELD OF THE INVENTION

The present invention relates to a technique for
embedding a digital watermark in a document image, and
also to a technique for extracting the embedded digital
10 watermark.

BACKGROUND OF THE INVENTION

As a copyright protection method upon
distributing digital data such as image data, audio
15 data, and the like on the Internet, digital
watermarking attracts a lot of attention. Digital
watermarking is a technique for embedding information
so as to be imperceptible to a human being. For
example, as a digital watermarking technique for a
20 multi-valued image, various methods that exploit the
redundancy of the density values of multi-valued pixels
are known.

On the other hand, a binary image such as a
document image has small redundancy, and it is
25 difficult to apply the digital watermarking technique
to such image. However, some digital watermarking
methods that exploit unique features of document images

are known. For example, a method of shifting the baseline of a line (e.g., see Japanese Patent No. 3,136,061), a method of manipulating an inter-word space length (e.g., see U.S. Patent No. 6,086,706 and
5 Japanese Patent Laid-Open No. 9-186603 (U.S. Patent No. 5,861,619)), a method of manipulating an inter-character space length (e.g., see "Electronic document data hiding technique using inter-character space", The 1998 IEEE Asia-Pacific Conf. On Circuits
10 and Systems, 1998, pp. 419 - 422), a method of rotating a character to change its inclination (e.g., see Yasuhiro Nakamura & Kineo Matsui, "Digital Watermarking onto Japanese Documents by Seal Image", IPSJ Journal Vol. 38, No. 11, Nov. 1997), and the like are known.

15 However, since a document image has small redundancy, and the conventional methods proposed so far embed information by changing two variables, i.e., the baseline of a line, inter-word space, or rotation of a character, the changed points stand out (i.e.,
20 image quality deteriorates considerably). For this reason, embedding of information to a document image may be detected by a third party.

SUMMARY OF THE INVENTION

25 The present invention has been made in consideration of the aforementioned problems, and has as its object to provide a technique that can embed a

digital watermark data sequence in a document image while suppressing deterioration of the image quality.

In order to achieve the above object, for example, an apparatus of the present invention comprises the following arrangement.

That is, an apparatus for embedding a digital watermark in a document image, comprising:

outer shape detection means for detecting outer shapes of characters in the document image, which include first and third outer shapes in a first line serving as a reference line, a second outer shape in a second line as a line other than the reference line, and a fourth outer shape in a third line as a line other than the reference line; and

control means for controlling at least one of outer shapes included in respective pairs so as to set a parameter between the first and second outer shapes and a parameter between the third and fourth outer shapes to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example, a method of the present invention comprises the following arrangement.

That is, a method for embedding a digital watermark in a document image, comprising:

an outer shape detection step of detecting outer shapes of characters in the document image, which

include first and third outer shapes in a first line serving as a reference line, a second outer shape in a second line as a line other than the reference line, and a fourth outer shape in a third line as a line
5 other than the reference line; and

a control step of controlling at least one of outer shapes included in respective pairs so as to set a parameter between the first and second outer shapes and a parameter between the third and fourth outer
10 shapes to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example, an apparatus of the present invention comprises the following arrangement.

15 That is, an apparatus for embedding a digital watermark in a document image, comprising:

outer shape detection means for detecting outer shapes of characters in the document image;

reference calculation means for setting
20 references at given intervals in a column direction;
and

control means for controlling at least one of second and third outer shapes of outer shapes in a line of interest, so as to set a parameter between the
25 reference, which is located between a first outer shape and the second outer shape that neighbors the first outer shape, and the second outer shape, and a

parameter between the reference, which is located between the second outer shape and the third outer shape that neighbors the second outer shape, and the third outer shape, to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example, a method of the present invention comprises the following arrangement.

10 That is, a method for embedding a digital watermark in a document image, comprising:

 an outer shape detection step of detecting outer shapes of characters in the document image;

 a reference calculation step of setting
15 references at given intervals in a column direction;
and

 a control step of controlling at least one of second and third outer shapes of outer shapes in a line of interest, so as to set a parameter between the
20 reference, which is located between a first outer shape and the second outer shape that neighbors the first outer shape, and the second outer shape, and a parameter between the reference, which is located between the second outer shape and the third outer
25 shape that neighbors the second outer shape, and the third outer shape, to be different from each other in

accordance with digital watermark information to be embedded.

In order to achieve the above object, for example, an apparatus of the present invention comprises the following arrangement.

That is, an apparatus for embedding a digital watermark in a document image, comprising:

outer shape detection means for detecting outer shapes of characters in the document image;

reference calculation means for setting references at given intervals in a column direction; and

control means for controlling a second outer shape of outer shapes in a line of interest, so as to set a parameter between the reference, which is located between a first outer shape and the second outer shape that neighbors the first outer shape, and the second outer shape, to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example, a method of the present invention comprises the following arrangement.

That is, a method for embedding a digital watermark in a document image, comprising:

an outer shape detection step of detecting outer shapes of characters in the document image;

a reference calculation step of setting references at given intervals in a column direction; and

a control step of controlling a second outer shape of outer shapes in a line of interest, so as to set a parameter between the reference, which is located between a first outer shape and the second outer shape that neighbors the first outer shape, and the second outer shape, to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example, an apparatus of the present invention comprises the following arrangement.

That is, an apparatus for embedding a digital watermark in a document image, comprising:

outer shape detection means for detecting outer shapes of characters in the document image;

reference calculation means for setting references at given intervals in a column direction; and

control means for controlling to set a parameter between a first reference position calculated by the reference calculation means, and a first circumscribing rectangle in a first line, and a parameter between a second reference position calculated by the reference calculation means and a second circumscribing rectangle

in a second line, to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example,
5 a method of the present invention comprises the following arrangement.

That is, a method for embedding a digital watermark in a document image, comprising:

an outer shape detection step of detecting outer
10 shapes of characters in the document image;

a reference calculation step of setting references at given intervals in a column direction;
and

a control step of controlling to set a parameter
15 between a first reference position calculated by the reference calculation means, and a first circumscribing rectangle in a first line, and a parameter between a second reference position calculated by the reference calculation means and a second circumscribing rectangle
20 in a second line, to be different from each other in accordance with digital watermark information to be embedded.

In order to achieve the above object, for example,
an apparatus of the present invention comprises the
25 following arrangement.

That is, an apparatus for extracting data embedded in a document image, comprising:

setting means for setting a first line;

outer shape detection means for detecting outer shapes of characters in the document image, which include first and third outer shapes in the first line serving as a reference line, a second outer shape in a
5 second line as a line other than the reference line, and a fourth outer shape in a third line as a line other than the reference line;

and

10 extraction means for comparing a parameter between the first and second outer shapes and a parameter between the third and fourth outer shapes, and extracting data according to a comparison result of the parameters as the data embedded in the document
15 image.

In order to achieve the above object, for example, a method of the present invention comprises the following arrangement.

That is, a method for extracting data embedded
20 in a document image, comprising:

a setting step of setting a first line;

an outer shape detection step of detecting outer shapes of characters in the document image, which include first and third outer shapes in the first line serving as a reference line, a second outer shape in a
25 second line as a line other than the reference line,

and a fourth outer shape in a third line as a line
other than the reference line;

and

an extraction step of comparing a parameter
5 between the first and second outer shapes and a
parameter between the third and fourth outer shapes,
and extracting data according to a comparison result of
the parameters as the data embedded in the document
image.

10 In order to achieve the above object, for example,
an apparatus of the present invention comprises the
following arrangement.

That is, an apparatus for extracting data
embedded in a document image, comprising:

15 outer shape detection means for detecting outer
shapes of characters in the document image;

reference calculation means for setting
references at given intervals in a column direction;
and

20 extraction means for comparing a first parameter
between the reference, which is located between a first
outer shape and a second outer shape that neighbors the
first outer shape, and the second outer shape, and a
second parameter between the reference which is located
25 between the second outer shape and a third outer shape
that neighbors the second outer shape, and the third
outer shape, of the outer shapes in a line of interest,

and extracting data corresponding to a comparison result of the parameters as data embedded using the first and second parameters.

In order to achieve the above object, for example,
5 a method of the present invention comprises the following arrangement.

That is, a method for extracting data embedded in a document image, comprising:

an outer shape detection step of detecting outer
10 shapes of characters in the document image;

a reference calculation step of setting references at given intervals in a column direction;
and

an extraction step of comparing a first parameter
15 between the reference, which is located between a first outer shape and a second outer shape that neighbors the first outer shape, and the second outer shape, and a second parameter between the reference which is located between the second outer shape and a third outer shape
20 that neighbors the second outer shape, and the third outer shape, of the outer shapes in a line of interest, and extracting data corresponding to a comparison result of the parameters as data embedded using the first and second parameters.

25 In order to achieve the above object, for example, an apparatus of the present invention comprises the following arrangement.

That is, an apparatus for extracting data
embedded in a document image, comprising:

outer shape detection means for detecting outer
shapes of characters in the document image;

5 reference calculation means for setting
references at given intervals in a column direction;
and

extraction means for comparing a first parameter
between a first reference position calculated by the
10 reference calculation means, and a first circumscribing
rectangle in a first line, and a second parameter
between the second reference position calculated by the
reference calculation means, and a second
circumscribing rectangle in a second line, and
15 extracting data corresponding to a comparison result of
the parameters as data embedded using the first and
second parameters.

In order to achieve the above object, for example,
a method of the present invention comprises the
20 following arrangement.

That is, a method for extracting data embedded
in a document image, comprising:

an outer shape detection step of detecting outer
shapes of characters in the document image;

25 a reference calculation step of setting
references at given intervals in a column direction;
and

an extraction step of comparing a first parameter between a first reference position calculated in the reference calculation step, and a first circumscribing rectangle in a first line, and a second parameter

5 between the second reference position calculated in the reference calculation step, and a second circumscribing rectangle in a second line, and extracting data corresponding to a comparison result of the parameters as data embedded using the first and second parameters.

10 In order to achieve the above object, for example, an apparatus of the present invention comprises the following arrangement.

That is, an apparatus for extracting data embedded in a document image, comprising:

15 outer shape detection means for detecting outer shapes of characters in the document image;

reference calculation means for setting references at given intervals in a column direction; and

20 extraction means for comparing a parameter between the reference, which is located between a first outer shape and the second outer shape that neighbors the first outer shape, and the second outer shape, of the outer shapes in a line of interest, each other,
25 and extracting data corresponding to a comparison result of the parameters as data embedded in the document image.

In order to achieve the above object, for example, a method of the present invention comprises the following arrangement.

That is, a method for extracting data embedded
5 in a document image, comprising:

an outer shape detection step of detecting outer shapes of characters in the document image;

a reference calculation step of setting references at given intervals in a column direction;

10 and

an extraction step of comparing a parameter between the reference, which is located between a first outer shape and the second outer shape that neighbors the first outer shape, and the second outer shape, of
15 the outer shapes in a line of interest, each other, and extracting data corresponding to a comparison result of the parameters as data embedded in the document image.

Other features and advantages of the present
20 invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

25

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a view for explaining the method of embedding a digital watermark data sequence according to the first embodiment of the present invention;

Fig. 2 is a view showing an example of formation of pairs;

Fig. 3 is a block diagram showing the basic arrangement of a computer which serves as a digital watermark embedding apparatus, and a digital watermark extraction apparatus for extracting a digital watermark data sequence from a document image embedded with the digital watermark data sequence according to the third embodiment of the present invention;

Fig. 4 is a flow chart of the process for embedding a digital watermark data sequence according to the first embodiment of the present invention;

Fig. 5 is a flow chart of the process for extracting a digital watermark data sequence according to the first embodiment of the present invention;

Fig. 6 is a view for explaining a digital watermark embedding method according to the second embodiment of the present invention;

Fig. 7 is a view for explaining a method of embedding more digital watermark data using circumscribing rectangles, which are not used in the digital watermark embedding method according to the second embodiment of the present invention;

Fig. 8 is a view for explaining a digital watermark embedding method according to the third embodiment of the present invention;

Fig. 9 is a view for explaining a method of embedding more digital watermark data using circumscribing rectangles, which are not used in the digital watermark embedding method according to the third embodiment of the present invention;

Fig. 10 is a view for explaining a case wherein lines include different numbers of characters, i.e., circumscribing rectangles;

Fig. 11 is a view for explaining a digital watermark embedding method according to the fourth embodiment of the present invention;

Fig. 12 is a view for explaining a digital watermark embedding method according to the fifth embodiment of the present invention;

Fig. 13 is a flow chart of the digital watermark embedding process according to the fourth embodiment of the present invention; and

Fig. 14 is a flow chart of the digital watermark extraction process according to the fourth embodiment of the present invention.

5 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail in accordance with the accompanying drawings.

[First Embodiment]

10 A method of embedding a digital watermark data sequence according to this embodiment will be described below using Fig. 1. Fig. 1 is a view for explaining the method of embedding a digital watermark data sequence according to this embodiment.

15 Rectangles A1 to A7 and B1 to B7 indicate circumscribing rectangles of characters in a document image. Circumscribing rectangles A1 to A7 are those of characters of A-th line in the document image. Likewise, circumscribing rectangles B1 to B7 are those
20 of characters of B-th line in the document image. These circumscribing rectangles are extracted using a document analysis technique.

The circumscribing rectangle of each character is a rectangle that circumscribes a character, and
25 information indicating a region which is to undergo character recognition. As a method of obtaining circumscribing rectangles of characters, the pixel

values of a document image are mapped on the vertical coordinate axis to segment the document image into lines by searching for blank portions (portions where no black characters are present), and determining lines
5 (character strings that line up horizontally). After that, the document image is mapped on the horizontal coordinate axis for each line to search for blank portions, thus segmenting the line into characters. In this way, respective characters can be extracted
10 (detected) as circumscribing rectangles. As this method, a method disclosed in, e.g., Japanese Patent Laid-Open No. 6-68301 (U.S. Patent No. 5,680,479) may be used.

In the following description, an m -th
15 circumscribing rectangle from the leftmost one in Fig. 1 in the n -th line from the uppermost one in Fig. 1 may be expressed as circumscribing rectangle $n-m$. In Fig. 1, reference numeral 101 denotes a distance between the right edges of circumscribing rectangles A1
20 and B2; 102, a distance between the right edges of circumscribing rectangles A3 and B4; and 103, a distance between the right edges of circumscribing rectangles A5 and B6. As described above, the method of embedding a digital watermark data sequence
25 according to this embodiment changes these distances in accordance with data to be embedded.

The method of embedding the digital watermark data sequence will be described below. Fig. 3 shows the basic arrangement of a computer which serves as a digital watermark embedding apparatus, and also a
5 digital watermark extraction apparatus for extracting a digital watermark data sequence from a document image embedded with the digital watermark data sequence according to this embodiment. Note that use of all blocks shown in Fig. 3 is not indispensable to
10 implement the embedding method and an extraction method to be described later.

Referring to Fig. 3, a computer 301 is a prevalent personal computer or workstation, and can receive, edit, and save an image scanned by a scanner
15 317. Also, the computer 301 can print an image scanned by the scanner 317 on a print medium such as a paper sheet, OHP film, or the like using a printer 316. Note that various user's instructions can be input using a mouse 313 and keyboard 314.

20 In the computer 301, respective blocks to be described below are connected via a bus 307 and can exchange various data. An MPU 302 controls the operations of respective blocks in the computer 301, and executes programs stored in a main memory 303,
25 which comprises a RAM, so as to implement a series of processes associated with embedding of a digital watermark data sequence (to be described later) and a

series of processes for extracting a digital watermark data sequence embedded in a document image by this embedding process.

The main memory 303 comprises an area for
5 temporarily storing programs and data loaded from an HDD 304, CD-ROM drive 309, DVD-ROM drive 310, FD drive 311, and the like, and also a work area for temporarily storing data to be processed when the MPU 302 executes various processes.

10 The hard disk drive (HDD) 304 can pre-store programs and document image data to be loaded onto the main memory 303, and can store processed document image data. An interface (I/F) 315 is connected to the scanner 317, which scans information recorded on a
15 document, film, or the like, and generates image data, and is used to input image data scanned by the scanner 317. An I/F 308 is connected to the printer 316 which prints image data, and transmits image data to be printed to the printer 316.

20 The CD-ROM drive 309 can read out data stored in a CD-ROM (CD-R/CD-RW) as one of external storage media, and can write data on the CD-R/CD-RW. The FD (floppy® disk) drive 311 can read out data from an FD and can write data on the FD as in the CD-ROM drive 309. The
25 DVD-ROM drive 310 can read out data from a DVD and can write data on the DVD as in the FD drive 311. When programs or printer drivers are stored in the CD-ROM,

FD, DVD-ROM, and the like, these programs are installed on the HDD 304, and are loaded onto the main memory 303 as needed.

An I/F 312 is connected to the mouse 313 and
5 keyboard 314 to receive input instructions from them.
A monitor 306 is a display device which can display an extraction process result of a digital watermark data sequence and its progress. Furthermore, a video controller 305 transmits display data to the monitor
10 306.

The digital watermark data sequence embedding process to be executed by the computer with the above arrangement (by the MPU 302 in practice) will be described below with reference to Fig. 4 which is the
15 flow chart of that process. The progress of the following processes may be displayed on the monitor 306 as needed.

A document image in which a digital watermark is to be embedded is loaded onto the main memory 303 in
20 response to a user's input instruction using the mouse 313 or keyboard 314 (step S400). Assume that this document image is obtained by scanning a print medium such as a paper sheet or the like on which a document is printed, and converting the scan result into bitmap
25 data. However, the method of obtaining a document image is not limited to such specific method. For example, document data created by a general document

editor or document data which is loaded from the CD-ROM drive 309, DVD-ROM drive 310, or FD drive 311 onto the main memory 303 may be converted into bitmap data to generate a document image. Also, the apparatus may
5 comprise a network I/F that can connect to a network such as a LAN, Internet, or the like, and may externally receive and obtain a document image via the network. In any of the above cases, a document image is bitmap data.

10 The document image as bitmap data undergoes the aforementioned document analysis to obtain circumscribing rectangles of characters (step S401). When the user inputs a digital watermark data sequence consisting of 1 or 0 using the keyboard 314 or mouse
15 313, this data sequence is output to the main memory 303 via the I/F 312, and is stored in the main memory 303 (step S402).

 The distance between the right edges of circumscribing rectangles in a pair (first pair) of
20 rectangles $n-m$ and $(n+1)-(m+1)$ is calculated as d_1 . Taking Fig. 1 as an example, distance d_1 corresponds to, e.g., the distance 101 between the right edges of circumscribing rectangles A1 and B2. Also, the distance between the right edges of circumscribing
25 rectangles in a pair (second pair) of rectangles $n-(m+2)$ and $(n+1)-(m+3)$ is calculated as d_2 . Taking Fig. 1 as an example, distance d_2 corresponds to, e.g.,

the distance 102 between the right edges of
circumscribing rectangles A3 and B4. That is, these
distances d1 and d2 are calculated in step S403.

If data to be embedded is 1, the flow advances to
5 step S405 to execute one or a combination of the
following two change processes so as to satisfy $d1 > d2$
(step S405).

- The size of circumscribing rectangle B2 in the
column direction is increased or the size of
10 circumscribing rectangle B4 in the column direction is
decreased (a change in size).

- The position of circumscribing rectangle B2 is
moved toward the circumscribing rectangle B3 side or
the position of circumscribing rectangle B4 is moved
15 toward the circumscribing rectangle B3 side (a change
in position).

An instruction for one or a combination of these
two change processes to be executed may be determined
in advance or may be input by the user.

20 On the other hand, if data to be embedded is 0,
the flow advances to step S406 to execute one or a
combination of the following two change processes so as
to satisfy $d1 < d2$ (step S406).

- The size of circumscribing rectangle B2 in the
25 column direction is decreased or the size of
circumscribing rectangle B4 in the column direction is
increased (a change in size).

•The position of circumscribing rectangle B2 is moved toward the circumscribing rectangle B1 side or the position of circumscribing rectangle B4 is moved toward the circumscribing rectangle B5 side (a change
5 in position).

An instruction for one or a combination of these two parameter change processes to be executed may be determined in advance or may be input by the user. Also, upon execution of the control process that
10 changes the position and/or size of the circumscribing rectangle, the position and/or size of a character circumscribed by the circumscribing rectangle are/is similarly changed accordingly.

Circumscribing rectangles to be changed in the
15 above position change process and/or size change process are not limited to those described above, and one of $d1 > d2$ and $d1 < d2$ need only be met in correspondence with information to be embedded.

The change process in step S405 or S406 is
20 executed to obscure the change portion, i.e., to minimize deterioration of the image quality.

Referring back to Fig. 4, if data to be embedded still remains, the flow returns to step S403 to repeat the above processes. For example, if data to be
25 embedded still remains, the distance between the right edges of circumscribing rectangles in a pair (first pair) of circumscribing rectangles $n-(m+4)$ and

(n+1)-(m+5) is calculated as d1, and the distance between the right edges of circumscribing rectangles in a pair (second pair) of circumscribing rectangles n-(m+6) and (n+1)-(m+7) is calculated as d2, in step
5 S403. Then, the processes in step S404 and subsequent steps are repeated.

A method of extracting a digital watermark data sequence embedded by the aforementioned process will be described below. As described above, the process for
10 extracting a digital watermark data sequence is also executed by the computer shown in Fig. 3. Fig. 5 is a flow chart showing the process to be executed by the computer (the MPU 302 in practice) to extract a digital watermark data sequence embedded by the aforementioned
15 process.

A document image embedded with a digital watermark data sequence (to be referred to as a watermarked image hereinafter) is loaded onto the main memory 303 in response to a user's input instruction
20 using the mouse 313 or keyboard 314 (step S500). Assume that this watermarked image is obtained by scanning, using the scanner 317, a print medium such as a paper sheet, OHP film, or the like on which a watermarked image generated by the above embedding
25 process is printed by the printer 317, and converting the scan result into bitmap data. However, the method of obtaining a watermarked image is not limited to such

specific method. For example, the watermarked image may be loaded from the HDD 304, CD-ROM drive 309, DVD-ROM drive 310, or FD drive 311 onto the main memory 303. Also, the apparatus may comprise a network I/F
5 that can connect to a network such as a LAN, Internet, or the like, and may externally receive and obtain the watermarked image via the network.

The watermarked image undergoes the aforementioned document analysis to obtain
10 circumscribing rectangles of characters (step S501). The process in this step is the same as the processing contents of step S401.

Next, distance $d1$ between circumscribing rectangles $n-m$ and $(n+1)-(m+1)$ and distance $d2$ between
15 circumscribing rectangles $n-(m+2)$ and $(n+1)-(m+3)$ are calculated (step S502). If $d1 > d2$ (step S503), the flow advances to step S504 to record embedded data as 1 in the main memory 303 (step S504). On the other hand, if $d1 < d2$, the flow advances to step S505 to record
20 embedded data as 0 in the main memory 303 (step S505).

It is then checked if circumscribing rectangles to be processed still remain (step S506). For example, if circumscribing rectangles to be processed still remain, distance $d1$ between circumscribing rectangles
25 $n-(m+4)$ and $(n+1)-(m+5)$ and distance $d2$ between circumscribing rectangles $n-(m+6)$ and $(n+1)-(m+7)$ are calculated in step S502 to repeat the processes in step

S503 and subsequent steps. If the number of embedded digital watermark data is known in advance, it may be determined whether or not those data have been recorded on the main memory 303.

5 If it is determined in step S506 that no circumscribing rectangle to be processed remains, the data sequence recorded in the main memory 303 in steps S504 and S505 can be obtained as a digital watermark data sequence. With the above process, the data
10 sequence can be extracted from a document image in which the digital watermark data sequence is embedded by the aforementioned method.

 In the aforementioned embedding method of a digital watermark into a document image, since the
15 distance between circumscribing rectangles in different lines is changed in place of that between circumscribing rectangles in a single line, a portion to be changed can be distributed over the entire document image in place of changing the distance
20 between circumscribing rectangles in a single line. Hence, a change in document image is hardly recognized by the human eye, and the image quality of the document image in which the digital watermark is embedded can be suppressed consequently.

25 In this embodiment, when two circumscribing rectangles form one pair, the line positions and the positions of the circumscribing rectangles from the

leftmost rectangles in these lines are each different by one. However, the line positions of circumscribing rectangles may be spaced by two or more lines, and the positions of the circumscribing rectangles from the leftmost rectangles in these lines may be spaced by two or more rectangles. Also, respective pairs may have different positional relationships between circumscribing rectangles which belong to them.

Fig. 2 shows an example of formation of pairs.

In Fig. 2, A1 and C3, A2 and C4, and A5 and C7 form pairs. Also, distances between circumscribing rectangles may be selected by different methods in respective pairs. For example, the distance between the right edge of one circumscribing rectangle and the left edge of the other circumscribing rectangle may be used, or either the distance between the right edges of the two circumscribing rectangles or the distance between the left edges of the two circumscribing rectangles may be used. When the method of selecting the distance is changed (e.g., for respective pairs) in this manner, the embedding method can become complex, and the secrecy of information to be embedded can be improved. Furthermore, combinations of lines may be complicated by selecting d1 from the distances between circumscribing rectangles in lines A and C, and selecting d2 from those in lines A and B.

However, when a digital watermark data sequence embedded by the above process is extracted, information indicating the positional relationship between circumscribing rectangles that belong to each pair, and
5 information indicating the method of selecting the distance are required for each pair (this embodiment requires only one each information since all pairs have the same positional relationship between circumscribing rectangle and the same method of selecting the
10 distance).

Also, circumscribing rectangles between which distances d_1 and d_2 are to be calculated may be selected using a pseudo random number in accordance with digital watermark data to be embedded. Taking
15 Fig. 1 as an example, when a pseudo random number is "0", the distance 101 is selected as d_1 , and the distance 102 is selected as d_2 ; when a pseudo random number is "1", the distance 101 is selected as d_1 , and the distance 103 is selected as d_2 ; and so forth.

20 [Second Embodiment]

In the first embodiment, two pairs of circumscribing rectangles, i.e., four circumscribing rectangles are required to embed 1-bit digital watermark data. This embodiment has as its object to
25 reduce the number of circumscribing rectangles used to embed 1-bit digital watermark data, and to embed more digital watermark data than the digital watermark

embedding method according to the first embodiment
using a limited number of circumscribing rectangles.
Note that the digital watermark embedding method
according to this embodiment is executed by the MPU 302
5 in the apparatus with the arrangement shown in Fig. 3
as in the first embodiment. In addition, the same
techniques as those in the first embodiment are
basically used unless otherwise specified.

Fig. 6 is a view for explaining the digital
10 watermark embedding method according to this embodiment.
Referring to Fig. 6, rectangles A1 to A7 indicate
circumscribing rectangles which are arranged in a
single line as in Fig. 1, and rectangles B1 to B7 also
indicate circumscribing rectangles which are arranged
15 in a single line as in Fig. 1. Reference numeral 601
denotes a distance between the right edges of A1 and
B2; 602, a distance between the right edges of B2 and
A3; 603, a distance between the right edges of A3 and
B4; and 604, a distance between the right edges of A4
20 and B5.

The flow chart of the digital watermark embedding
process according to this embodiment basically follows
the flow shown in Fig. 4. Taking the circumscribing
rectangles shown in Fig. 6 as an example, d1 and d2 to
25 be calculated in step S403 are respectively the
distances 601 and 602. If data to be embedded is 1,

one or a combination of the following two change processes is executed in step S405 to meet $d1 > d2$.

•The size of circumscribing rectangle A1 in the column direction is decreased or the size of circumscribing rectangle A3 in the column direction is decreased (a change in size).

•The position of circumscribing rectangle B2 is moved toward the circumscribing rectangle B3 side or the position of circumscribing rectangle A3 is moved toward the circumscribing rectangle A2 side (a change in position).

On the other hand, if data to be embedded is 0, one or a combination of the following two change processes is executed in step S406 to meet $d1 < d2$.

•The size of circumscribing rectangle A1 in the column direction is increased or the size of circumscribing rectangle A3 in the column direction is increased (a change in size).

•The position of circumscribing rectangle B2 is moved toward the circumscribing rectangle B1 side or the position of circumscribing rectangle A3 is moved toward the circumscribing rectangle A4 side (a change in position).

An instruction for one or a combination of these two change processes to be executed may be determined in advance or may be input by the user. Also, upon execution of the control process that changes the

position and/or size of the circumscribing rectangle, the position and/or size of a character circumscribed by the circumscribing rectangle are/is similarly changed accordingly.

5 Circumscribing rectangles to be changed in the above position change process and/or size change process are not limited to those described above, and one of $d1 > d2$ and $d1 < d2$ need only be met in correspondence with information to be embedded. In the
10 above process, distance $d2$ is preferably changed without changing distance $d1$.

 If it is determined in step S407 that data to be embedded still remains, the flow returns to step S403 to repeat the aforementioned process by selecting the
15 distance 602 as $d1$ and the distance 603 as $d2$. In this case, the distance 603 is changed without changing the aforementioned relationship between the distances 601 and 602.

 As described above, in the digital watermark
20 embedding method according to this embodiment, the number of circumscribing rectangles required to embed 1-bit data is three upon embedding the first 1 bit, and only one new circumscribing rectangle is used to embed each of subsequent bits. Except for the first 1 bit,
25 1-bit data can be embedded using one circumscribing rectangle. Hence, when digital watermark data is embedded using a limited number of circumscribing

rectangles, the digital watermark embedding method according to this embodiment can embed more data than the first embodiment.

The method of extracting digital watermark data from a document image in which digital watermark data is embedded according to the aforementioned digital watermark embedding method is basically the same as the first embodiment except for the method of selecting distances $d1$ and $d2$ (the method of selecting $d1$ and $d2$ in the aforementioned digital watermark embedding process). That is, the process according to the flow chart shown in Fig. 5 is executed. Also, the process for extracting a digital watermark data sequence is executed by the computer (MPU 302) shown in Fig. 3.

Also, when circumscribing rectangles which are not used in the digital watermark embedding method according to this embodiment are further used, more digital watermark data can be embedded. Fig. 7 is a view for explaining this method. Rectangles A1 to A7 and B1 to B7 are the same as those shown in Fig. 6. In this embodiment, circumscribing rectangles B1, A2, B3, A4, B5, and A6 are not used to embed digital watermark data. Hence, since the process of this embodiment is executed by selecting a distance 701 between the right edges of B1 and A2 as $d1$, and a distance 702 between the right edges of A2 and B3 as $d2$, as shown in Fig. 7, digital watermark data can be embedded using

circumscribing rectangles which are not used in the digital watermark embedding method according to this embodiment, and more data can be embedded.

[Third Embodiment]

5 The digital watermark embedding method according to the second embodiment has a merit that it can embed more data than that of the first embodiment. However, since the changed positions (those to which distances d_1 and d_2 are applied) are denser than the first
10 embodiment, the image quality of a document image after embedding is more likely to deteriorate.

 To solve this problem, the digital watermark embedding method according to this embodiment embeds all data to be embedded using three circumscribing
15 rectangles, but sets each consisting of three circumscribing rectangles are separated from each other. The digital watermark embedding method according to this embodiment will be described below using Fig. 8. Note that the digital watermark embedding method
20 according to this embodiment is executed by the MPU 302 in the apparatus with the arrangement shown in Fig. 3 as in the first embodiment. In addition, the same techniques as those in the first embodiment are basically used unless otherwise specified.

25 Fig. 8 is a view for explaining the digital watermark embedding method according to this embodiment. Referring to Fig. 8, rectangles A1 to A7 indicate

circumscribing rectangles which are arranged in a single line as in Fig. 6, and rectangles B1 to B7 also indicate circumscribing rectangles which are arranged in a single line as in Fig. 6. Reference numeral 801
5 denotes a distance between the right edges of A1 and B2; 802, a distance between the right edges of B2 and A3; 803, a distance between the right edges of A4 and B5; and 804, a distance between the right edges of A5 and B6. The digital watermark embedding method
10 according to this embodiment embeds each bit of digital watermark data using three circumscribing rectangles by the same method as that upon embedding the first 1 bit in the second embodiment, but the method of selecting three circumscribing rectangles is different from the
15 second embodiment. That is, as shown in Fig. 8, sets each consisting three circumscribing rectangles (a set of A1, B2, A3 and a set of A4, B5, and A6 in Fig. 8) are separated by one circumscribing rectangle.

Then, digital watermark data is embedded by
20 applying the same method as that upon embedding the first 1 bit in the second embodiment to the respective sets. At this time, circumscribing rectangles A1 and A4 are not changed. In this way, since the changed portions are distributed, deterioration of the image
25 quality of a document image after digital watermark data is embedded can be suppressed.

The method of extracting digital watermark data from a document image in which digital watermark data is embedded according to the aforementioned digital watermark embedding method is basically the same as the first embodiment except for the method of selecting distances d_1 and d_2 (the method of selecting d_1 and d_2 in the aforementioned digital watermark embedding process). That is, the process according to the flow chart shown in Fig. 5 is executed. Also, the process for extracting a digital watermark data sequence is executed by the computer (MPU 302) shown in Fig. 3.

Also, when circumscribing rectangles which are not used in the digital watermark embedding method according to this embodiment are further used, more digital watermark data can be embedded. Fig. 9 is a view for explaining this method. Rectangles A1 to A7 and B1 to B7 are the same as those shown in Fig. 8. In this embodiment, circumscribing rectangles B1, A2, B3, A4, B5, and A6 are not used to embed digital watermark data. Hence, since the process of this embodiment is executed by selecting a distance 901 between the right edges of B1 and A2 as d_1 , and a distance 902 between the right edges of A2 and B3 as d_2 , as shown in Fig. 9, digital watermark data can be embedded using circumscribing rectangles which are not used in the digital watermark embedding method according to this embodiment, and more data can be embedded.

Note that the respective sets are spaced by one circumscribing rectangle in this embodiment. However, the present invention is not limited to such specific space, and that space may be changed in consideration
5 of the number of circumscribing rectangles in the line direction of those included in a document image.

[Fourth Embodiment]

The first to third embodiments described above are implemented by comparing the distances between
10 circumscribing rectangles in different lines. However, this method is not efficient when respective lines have different numbers of characters, i.e., circumscribing rectangles, as shown in Fig. 10. For example, upon embedding a digital watermark by combining the first
15 and second lines, rectangles A5 to A7, C6, and C7 cannot be used and wasted since they have no characters to be combined. Hence, the digital watermark embedding method according to this embodiment embeds a digital
20 rectangles even when respective lines have different numbers of circumscribing rectangles, as exemplified in Fig. 10. Note that the digital watermark embedding method according to this embodiment is executed by the MPU 302 in the apparatus with the arrangement shown in
25 Fig. 3 as in the first embodiment. In addition, the same techniques as those in the first embodiment are basically used unless otherwise specified.

Fig. 11 is a view for explaining the digital watermark embedding method according to this embodiment. Circumscribing rectangles A1 to A7, B1 to B4, and C1 to C7 shown in Fig. 11 are the same as those shown in

5 Fig. 10. Referring to Fig. 11, reference numeral 1101 denotes a distance between the right edges of A1 and B2; 1102, a distance between the right edges of A2 and B3; 1103, a distance between the right edges of A1 and C2; 1104, a distance between the right edges of A2 and
10 C3; 1105, a distance between the right edges of A3 and C4; and 1106, a distance between the right edges of A4 and C5. The digital watermark embedding method according to this embodiment will be described below taken Fig. 11 as an example.

15 The flow chart of the digital watermark embedding process according to this embodiment basically follows the flow shown in Fig. 4, but which distances are to be calculated as d1 and d2 in step S403 is different from the above embodiment. Fig. 13 is a flow chart of the
20 digital watermark embedding process according to this embodiment.

Since the processes in steps S1301 to S1303 are the same as those in steps S400 to S402, a description thereof will be omitted. In step S1304, a reference
25 line is determined. Since this reference line is a line having the largest length, i.e., a line including the largest number of circumscribing rectangles, the

first line (a line including circumscribing rectangles A1 to A7) is selected in this case. More specifically, circumscribing rectangles obtained in step S1302 are counted for respective lines, and a line with the
5 largest count value is selected as the reference line. When a plurality of lines have the largest count value, a line closest to the first line is selected as the reference line.

Furthermore, a target line is selected in step
10 S1305. The target line is a line other than the reference line. In step S1305, one of lines other than the reference line, which is closest to the first line (second line in Fig. 11) is selected as the target line to be processed.

15 In step S1306, the distances 1101 and 1102 are respectively calculated as distances d1 and d2. That is, the distances between the right edges of circumscribing rectangles in the reference line and those in the target line are calculated as d1 and d2.
20 If data to be embedded is 1, the change process of the sizes and/or positions of circumscribing rectangles B2, B3, and the like is executed to satisfy $d1 > d2$; if data to be embedded is 0, the change process is executed to satisfy $d1 < d2$. In this embodiment, the
25 change process is not applied to the circumscribing rectangles in the reference line. Also, upon execution of the control process that changes the position and/or

size of the circumscribing rectangle, the position and/or size of a character circumscribed by the circumscribing rectangle are/is similarly changed accordingly.

5 If it is determined in step S1310 that data to be embedded still remains, the flow returns to step S1305. In this case, it is checked in step S1305 if the target line includes unused circumscribing rectangles. In the example of Fig. 11, the circumscribing rectangles used
10 in the target line, i.e., the line including circumscribing rectangles B1 to B4 are B2 and B3. Since B1 is not used as a rectangle to be processed, only B4 is an unused circumscribing rectangle in practice. In this embodiment, when two or more unused
15 circumscribing rectangles remain, the target line remains unchanged. However, when the number of unused circumscribing rectangles is less than 2, the target line is changed.

 In the example of Fig. 11, since the number of
20 unused circumscribing rectangles is one, the target line is shifted downward by one, and the third line, i.e., a line including circumscribing rectangles C1 to C7, is selected as a new target line in step S1305. Hence, the distances 1103 and 1104 are respectively
25 calculated as d1 and d2 in step S1306. That is, the distances between the right edges of circumscribing rectangles in the reference line and those in the

target line are calculated as $d1$ and $d2$. Then, the above processes are repeated for all lines after the second line.

With the above processes, although digital
5 watermark data cannot be embedded in the reference line, even when lines have different numbers of circumscribing rectangles, a larger number of circumscribing rectangles can be used compared to the above embodiment, thus efficiently embedding a digital
10 watermark.

The method of extracting digital watermark data from a document image in which digital watermark data is embedded according to the aforementioned digital watermark embedding method is basically the same as the
15 first embodiment except for the method of selecting distances $d1$ and $d2$ (the method of selecting $d1$ and $d2$ in the aforementioned digital watermark embedding process). Fig. 14 is a flow chart of the digital watermark extraction process according to this
20 embodiment. Also, the process for extracting a digital watermark data sequence is executed by the computer (MPU 302) shown in Fig. 3.

Since the processes in steps S1401 and S1402 are the same as those in steps S500 and S501, a description
25 thereof will be omitted. Also, in steps S1403 to S1405, the reference line and target line are determined, and $d1$ and $d2$ are calculated using circumscribing

rectangles in these lines as in steps S1304 to S1306. In step S1406 and subsequent steps, the same processes as those in step S503 and subsequent steps are executed.

Furthermore, it is determined in step S1404 if
5 the target line includes unused circumscribing rectangles (in this embodiment, if two or more unused circumscribing rectangles remain, the target line remains unchanged; if the number of unused circumscribing rectangles is less than 2, the target
10 line is changed). With this process, data embedded by the digital watermark embedding process according to this embodiment can be extracted.

The position of the reference line may be given as a key upon extracting a digital watermark. In this
15 case, circumscribing rectangles need not be counted for respective lines in step S1403, and the reference line can be determined based on this key.

In order to obtain distances d_1 and d_2 in this embodiment, the distances between the right edges of
20 circumscribing rectangles which are shifted one each in the column direction are calculated. However, the present invention is not limited to this, and the circumscribing rectangles may be shifted two or more each.

25 In this embodiment, after the distances 1101 and 1102 are calculated, the third line is selected as the target line. Alternatively, after the distances 1101

and 1102 are calculated, the distance 1102 may be selected as d1, and the distance between the right edges of A3 and B4 may be calculated as d2. Then, another digital watermark data may be embedded using
5 these d1 and d2 to embed more data.

[Fifth Embodiment]

In the fourth embodiment, digital watermark data cannot be embedded in the reference line, as described above. This embodiment allows to embed digital
10 watermark data in all lines even when respective lines have different numbers of circumscribing rectangles, as exemplified in Fig. 11. Note that the digital watermark embedding method according to this embodiment is executed by the MPU 302 in the apparatus with the
15 arrangement shown in Fig. 3 as in the first embodiment. In addition, the same techniques as those in the first embodiment are basically used unless otherwise specified.

Fig. 12 is a view for explaining the digital
20 watermark embedding process according to this embodiment. Referring to Fig. 12, circumscribing rectangles A1 to A4 and B1 to B7 are arranged in respective lines. Also, K1, K2, K3, and K4 are references set at given intervals. Pitches between K1
25 and K2, K2 and K3, and K3 and K4 will be respectively referred to as basic pitches in this embodiment. Note that this basic pitch is the average value of the

distances between the right edges of circumscribing rectangles in all lines, but may be obtained by other calculations.

Also, in Fig. 12, reference numeral 1201 denotes
5 a distance from K1 to the right edge of A2; 1202, a distance from K2 to the right edge of A3; 1203, a distance from K3 to the right edge of A4; 1204, a distance from K1 to the right edge of B2; 1205, a distance from K2 to the right edge of B3; 1206, a
10 distance from K3 to the right edge of B4; and 1207, a distance from K4 to the right edge of B4. The digital watermark embedding method according to this embodiment will be described below taking Fig. 12 as an example.

The flow chart of the digital watermark embedding
15 process according to this embodiment basically follows the flow shown in Fig. 4, but which distances are to be calculated as d1 and d2 in step S403 is different from the above embodiment. In this embodiment, the average value of the distances between circumscribing
20 rectangles in respective lines is calculated in step S403, and is stored in the main memory 303, HDD 304, or the like as the basic pitch. This basic pitch is also used as key information upon extracting a digital watermark.

25 In step S403, the distances between the references (K1, K2, K3, and K4 in Fig. 12), which are determined based on the basic pitch and are set between

neighboring circumscribing rectangles in the column direction in the first line, and the right edges of circumscribing rectangles, each of which appears immediately after the reference, are calculated. In
5 the example of Fig. 12, the distances 1201 and 1202 are calculated as d_1 and d_2 .

If data to be embedded is 1, the change process of the sizes and/or positions of circumscribing rectangles A2 and A3 is executed to satisfy $d_1 > d_2$; if
10 data to be embedded is 0, the change process is executed to satisfy $d_1 < d_2$. Also, upon execution of the control process that changes the position and/or size of the circumscribing rectangle, the position and/or size of a character circumscribed by the
15 circumscribing rectangle are/is similarly changed accordingly.

If it is determined in step S407 that data to be embedded still remains, the flow returns to step S403. In this case, it is checked in step S403 if the line to
20 be processed includes unused circumscribing rectangles. In the example of Fig. 12, in the lines including circumscribing rectangles A1 to A4, circumscribing rectangles A2 and A3 are used. Since A1 is not used as an object to be processed, only A4 is an unused
25 circumscribing rectangle in practice. In this embodiment, when two or more unused circumscribing rectangles remain, only the line to be processed is

successively used; when the number of circumscribing rectangles is less than 2, the next line is also selected as a line to be processed.

That is, in the example of Fig. 12, a line
5 including B1 to B7 is also selected as a line to be processed to calculate the distances 1203 and 1204 as d1 and d2, thus repeating the subsequent processes.

With the above processes, even when lines have different numbers of circumscribing rectangles, digital
10 watermark data can be embedded in all the lines.

The method of extracting digital watermark data from a document image in which digital watermark data is embedded according to the aforementioned digital watermark embedding method is basically the same as the
15 first embodiment except for the method of selecting distances d1 and d2 (the method of selecting d1 and d2 in the aforementioned digital watermark embedding process). That is, the process according to the flow chart shown in Fig. 5 is executed. In step S502, the
20 basic pitch may be calculated as in step S403, or the basic pitch calculated upon embedding may be loaded from the HDD 304 or the like as a key. Then, the distances between the references (K1, K2, K3, and K4 in Fig. 12), which are determined based on the basic pitch
25 and are set between neighboring circumscribing rectangles in the column direction, and the right edges of circumscribing rectangles, each of which appears

immediately after the reference, are calculated. In the example of Fig. 12, the distances 1201 and 1202 are calculated as d1 and d2.

Furthermore, it is determined in step S502 if the
5 line to be processed includes unused circumscribing rectangles (in this embodiment, if two or more unused circumscribing rectangles remain, the line to be processed is successively used; if the number of unused circumscribing rectangles is less than 2, the next line
10 is also selected as the line to be processed). With this process, data embedded by the digital watermark embedding process according to this embodiment can be extracted.

In this embodiment, when the entire document
15 image is enlarged or reduced in size, extraction of information may be disabled since the method of this embodiment uses comparison with a fixed value, i.e., the basic pitch, in place of relative comparison of distances unlike in the above embodiments. However,
20 when an information sequence upon embedding is random, i.e., when 1 and 0 have equivalent probabilities of occurrence, since the average value upon embedding may equal that upon extraction, the average of the distances between the right edges of circumscribing
25 rectangles upon embedding is expected to be nearly equal to that upon extraction.

Therefore, when the average value is used as the basic pitch, a process for calculating the distances between the right edges of circumscribing rectangles and then calculating their average may be executed in place of storing the basic pitch. Randomization of an information sequence can be easily realized by an encryption process of information to be embedded. In order to absorb offsets of the probabilities of occurrence of 1 and 0 in the information sequence to be embedded, several circumscribing rectangles at the end of a document or line may be used to correct such offset in place of using all circumscribing rectangles. That is, for example, when an information sequence to be embedded in one line includes "1"s 2 bits more than "0"s, the distances between circumscribing rectangles up to these "1" bits become larger than the average, but the distance between the subsequent two circumscribing rectangles can be set to be smaller than the average to correct the total length of the line. Note that no information is normally embedded in last several circumscribing rectangles. When the embedding and extraction sides share information indicating that correction information is embedded, the extraction side does not extract any information from last several circumscribing rectangles.

[Sixth Embodiment]

In the fifth embodiment, two circumscribing rectangles are used to embed 1-bit data. The digital watermark embedding method according to this embodiment embeds 1-bit data using one circumscribing rectangle.

- 5 Note that the digital watermark embedding method according to this embodiment is executed by the MPU 302 in the apparatus with the arrangement shown in Fig. 3 as in the first embodiment. In addition, the same techniques as those in the first embodiment are
- 10 basically used unless otherwise specified.

Taking Fig. 12 as an example, the positions and/or sizes of, e.g., A2 and A3 are changed to embed 1-bit data in the fifth embodiment. That is, two circumscribing rectangles are used to embed 1-bit data.

- 15 In this embodiment, the distance 1201 is calculated as d_1 , and the basic pitch as d_2 . If data to be embedded is 1, the process for changing the position or size of circumscribing rectangle A2 is executed to satisfy $d_1 > d_2$; if data to be embedded is 0, that process is
- 20 executed to satisfy $d_1 < d_2$. In this way, 1-bit data can be embedded using one circumscribing rectangle.

- The flow chart of the digital watermark embedding process according to this embodiment basically follows the flow shown in Fig. 4, but which distances are to be
- 25 calculated as d_1 and d_2 in step S403 is different from the above embodiment. In this embodiment, distance d_2 need not be calculated every process since it is a

fixed value. Since distance d_2 is the basic pitch, it may be held in the main memory 303 or HDD 304 as a key, as described above.

Also, the method of extracting digital watermark data from a document image in which digital watermark data is embedded according to the aforementioned digital watermark embedding method is basically the same as the first embodiment except for the method of selecting distances d_1 and d_2 (the method of selecting d_1 and d_2 in the aforementioned digital watermark embedding process).

That is, the basic pitch is calculated as in the fifth embodiment, or the key is acquired to be set as distance d_2 . Also, d_1 is changed for each data to be embedded like the distance 1201, distance 1202, distance 1203,... taking Fig. 12 as an example.

After that, the same processes as in the first embodiment are executed to extract data embedded by the digital watermark embedding process according to this embodiment.

However, when the entire document image is enlarged or reduced in size, extraction of information may be disabled since this method also uses comparison with a fixed value, i.e., the basic pitch, in place of relative comparison of distances unlike in the above embodiments. However, such difficulty can be coped

with by making randomization like in the fifth embodiment.

[Another Embodiment]

The objects of the present invention are also
5 achieved by supplying a storage medium (or recording medium), which records a program code of a software program that can implement the functions of the above-mentioned embodiments to the system or apparatus, and reading out and executing the program code stored
10 in the storage medium by a computer (or a CPU or MPU) of the system or apparatus. In this case, the program code itself read out from the storage medium implements the functions of the above-mentioned embodiments, and the storage medium which stores the program code
15 constitutes the present invention. The functions of the above-mentioned embodiments may be implemented not only by executing the readout program code by the computer but also by some or all of actual processing operations executed by an operating system (OS) running
20 on the computer on the basis of an instruction of the program code.

Furthermore, the functions of the above-mentioned embodiments may be implemented by some or all of actual processing operations executed by a CPU or the like
25 arranged in a function extension card or a function extension unit, which is inserted in or connected to the computer, after the program code read out from the

storage medium is written in a memory of the extension card or unit. When the present invention is applied to the storage medium, that storage medium stores the program codes corresponding to the aforementioned flow charts.

Also, the storage medium includes communication media such as communication cables used in networks such as the Internet, LAN, and the like. That is, when the program codes of the aforementioned embodiments are held in a server apparatus on a network, a program can be installed in a computer by downloading that program from the server apparatus to the computer via the network. Hence, the installed program is executed by a control circuit such as a CPU, MPU, or the like on the computer and, as a result, the computer can implement the functions of the aforementioned embodiments. Therefore, the aforementioned storage medium includes the communication media such as communication cables used in the networks.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the claims.